

# NIST Center for Neutron Research Safety Briefing



January 4, 2023

Photo credit: Brian Renegar

# NCNR – A National User Facility

30 beam instruments/experiments | ~40% of U.S. scientific productivity in neutrons



1200 patents



>3000 research participants/year



demand >> supply (2-3X)



~50 companies/year

# February 3, 2021 – Unplanned Shutdown

Fission products detected in confinement building upon normal reactor startup causing reactor to automatically shut down

10 staff members contaminated (sent home after decontamination)

No health/safety impacts to staff, public, or environment

The event posed no risk to personnel nor the community

The NIST reactor remains shut down until reactor readiness complete and NRC authorizes restart

---

Feb 4: confinement re-entry aborted due to elevated CO<sub>2</sub> level in lower levels of building



## **Technical Working Group Investigation – May 2021**

Determined root causes of event | Proposed corrective actions to prevent recurrence

## **Safety Evaluation Committee Investigation – August 2021**

Reviewed TWG report, root causes and event response | Proposed corrective actions and program improvements

## **External Consultants' Reviews – February 2022**

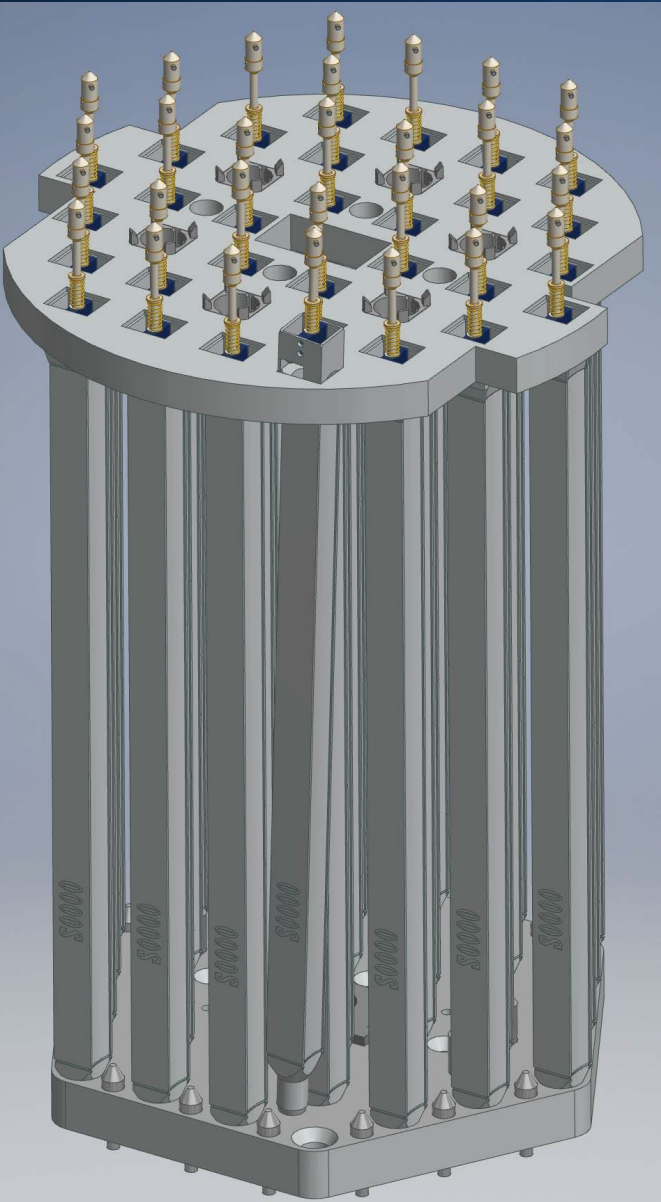
Reviewed incident, NIST's analysis, corrective actions, and the NIST-wide response to the incident

## **NRC Special Inspection – March 2022**

Evaluated NIST response and analysis | Identified 7 apparent license violations

## **CO<sub>2</sub> Exposure Investigation – May 2021**

Determined root causes of event | Proposed corrective actions to prevent recurrence



**Direct Cause:** A fuel element was not latched at reactor startup on February 3, 2021

Note: Unlatched fuel elements in 1981 and 1993 led to reactor shutdowns before damage could occur. The follow-on investigations in 1981 and 1993 were insufficient. Though changes were made in latch verification procedures, the 2021 event shows that effective corrective actions were not developed.

# 7 Apparent Violations



UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D. C. 20555-0001

March 16, 2022

EA-21-148

Dr. Robert Dimeo, Director  
National Institute of Standards and Technology  
NIST Center for Neutron Research  
U.S. Department of Commerce  
100 Bureau Drive, Mail Stop 8561  
Gaithersburg, MD 20899-8561

SUBJECT: NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY –  
U.S. NUCLEAR REGULATORY COMMISSION SPECIAL INSPECTION  
REPORT NO. 05000184/2022201

Dear Dr. Dimeo:

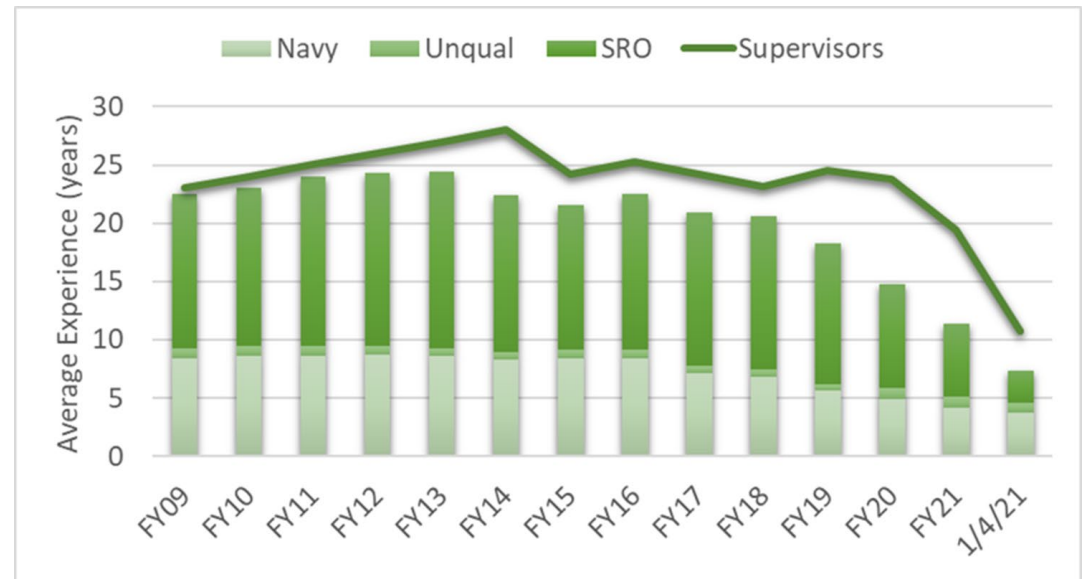
From February 9, 2021 – March 16, 2022, the U.S. Nuclear Regulatory Commission (NRC) staff conducted a special inspection at the National Institute of Standards and Technology (NIST) Center for Neutron Research facility. The NRC staff initiated the special inspection based upon the criteria specified in NRC Management Directive 8.3, "NRC Incident Investigation Program," following the event notification (EN 55094) received from your staff on February 3, 2021, regarding an alert declaration at the National Bureau of Standards test reactor (hereinafter the NIST test reactor). The special inspection utilized guidance in Inspection Procedure 93812, "Special Inspection Team," and Inspection Procedure 92701, "Followup." NIST supplemented the event notification by a 14-day report dated February 16, 2021 and amended on March 4, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML21048A149 and ML21070A183, respectively), which describe the circumstances that led to the alert declaration as a result of detecting fission products in the helium sweep and ventilation exhaust systems. Additionally, on March 2, 2021, in a related event notification (EN 55120), NIST informed the NRC that, based upon assessment of video surveillance of the reactor core and previously reported detection of fission products, your staff determined that the February 3, 2021, event violated the reactor's fuel cladding temperature safety limit in the technical specifications (TSs). Subsequently, NIST supplemented this notification by a 14-day report dated March 5, 2021, and amended on May 13, 2021 (ADAMS Accession Nos. ML21064A523 and ML21133A266, respectively).

On April 14, 2021, the NRC staff issued an interim special inspection report to provide an initial assessment of our understanding of the event sequence, consequences, and the licensee's response (ADAMS Accession No. ML21077A094). The enclosed final special inspection report presents the results of the NRC's special inspection activities. The NRC inspectors discussed the preliminary inspection findings with you and members of your staff at the conclusion of the special inspection on Thursday, March 10, 2022. A final exit briefing was conducted during a public meeting with you on Wednesday, March 16, 2022.

**March 16, 2022**

Leadership: failure to address loss of experience in Reactor Operations

- TS 2.1: Exceeding the safety limit (fuel cladding temperature)
- TS 3.1.3: Core configuration (FE 1175 not latched in place)
- TS 6.4: Procedures (inadequate fuel handling procedure)
- TS 6.4: Procedures (insufficient guidance monitoring abnormal nuclear channel readings during startup)
- TS 6.4: Inadequate emergency response procedures (though NCNR acted within required timeframe)
- TS 3.9.2.1: Fuel handling within the reactor vessel (failure to implement proper latch verification method to assure that FE 1175 was adequately latched)
- 10 CFR 50.59: Changes, tests, and experiments (refueling tool changes requiring a change to TS)



# Root Cause Analysis

## ROOT CAUSES

### Instruments, Equipment, & Tools

*Deficiencies in the fidelity of latch determination equipment and tools*

### Procedures

*Inadequacies in latch checking procedures*

*Procedural compliance not enforced*

### Qualifications & Training

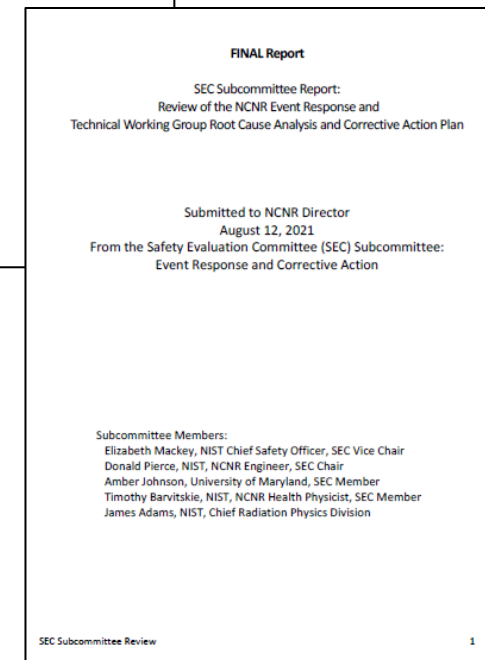
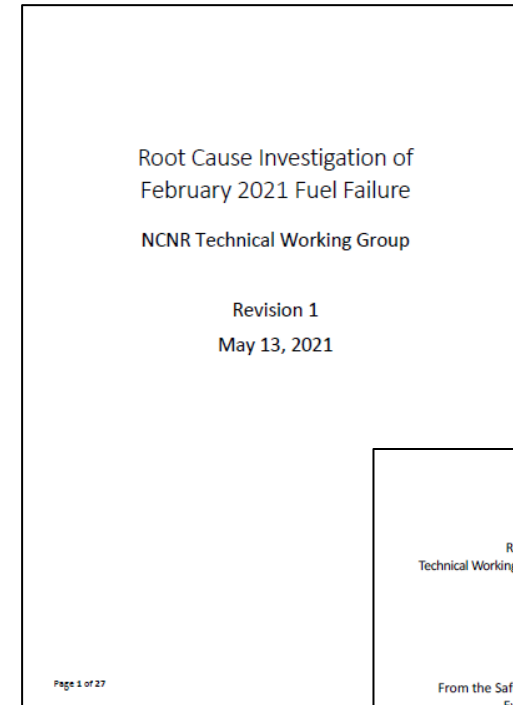
*Inadequacy of training and qualification program*

### Management Systems

*Insufficient change management system*

*Inadequate oversight of refueling operations*

*Culture of complacency in reactor operations group*



# Root Cause Analysis

## ROOT CAUSES

### Instruments, Equipment, & Tools

*Deficiencies in the fidelity of latch determination equipment and tools*

### Procedures

*Inadequacies in latch checking procedures*

*Procedural compliance not enforced*

### Qualifications & Training

*Inadequacy of training and qualification program*

### Management Systems

*Insufficient change management system*

*Inadequate oversight of refueling operations*

*Culture of complacency in reactor operations group*

Root causes directly related to broader safety culture issues

### Leadership Values and Actions

### Problem Identification and Resolution

### Work Processes

### Continuous Learning

### Safety Communications

### Questioning Attitude

### Environment for Raising Concerns



# Corrective Actions

## Instruments, Equipment, & Tools

- ***Develop visual check that fuel elements are latched***
- *Analyze and document that improved processes provide adequate defense against unlatching*
- *Assess efficacy of tools and implement changes as needed*
- *Modify index plate to facilitate rotation latch verification*
- *Discontinue use of height check form of latch verification*
- *Implement administrative controls to ensure that no tool contact with fuel head is permitted following visual check*
- *Improve refueling test stand for training*

## Procedures

- ***Rewrite procedures to capture all necessary detail and to be consistent with standard on procedure use & adherence***
- ***Require visual check that fuel elements are latched***
- ***Require training for all operations staff on procedure use and adherence***
- *Perform rotation latch check of all fuel elements prior to starting primary pumps. A redundant rotation latch check will be performed by a second qualified individual.*

## Qualifications & Training

- ***Require proficiency training prior to all refuelings***
- *Implement Continuous Learning Program: hands on + classroom*
- *Redesign operator and supervisor training programs with emphasis on critical activities*
- *Structure training with consistent performance requirements for critical operations tasks*

## Management Systems

- ***Expand change management program***
- ***Qualify supervisors on refueling and oversight***
- ***Add operations crew shift for training and maintenance***
- *Elevate Aging Reactor Management program*
- *Include tool changes in change management program*
- *All operations staff participate in corrective actions*
- *Add incentives for proactive improvements in safety*
- *Leadership field presence, staff engagement and mentoring*

# Confirmatory Order



August 1, 2022

UNITED STATES  
NUCLEAR REGULATORY COMMISSION  
WASHINGTON, D.C. 20555-0001

August 1, 2022

EA-21-148

Dr. Robert Dimeo, Director  
National Institute of Standards and Technology  
NIST Center for Neutron Research  
U.S. Department of Commerce  
100 Bureau Drive, Mail Stop 8561  
Gaithersburg, MD 20899-8561

SUBJECT: NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY, CENTER  
FOR NEUTRON RESEARCH – CONFIRMATORY ORDER

Dear Dr. Dimeo:

The enclosed Confirmatory Order is being issued to you as a result of a successful alternative dispute resolution (ADR) mediation session. The commitments outlined in the Confirmatory Order were made as part of a settlement agreement between the National Institute of Standards and Technology (NIST), Center for Neutron Research (NCNR or licensee) and the U.S. Nuclear Regulatory Commission (NRC). The settlement agreement concerns seven apparent violations of NRC requirements by the licensee, as discussed in our letter dated March 16, 2022 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML22056A361).

Our March 16, 2022, letter provided you with the results of an NRC special inspection that was conducted in response to an event at NCNR. Specifically, on February 3, 2021, NCNR made an emergency declaration (Alert) in response to an automatic reactor shutdown initiated by the detection of high radiation from the confinement exhaust stack. Subsequently, NCNR determined that a damaged fuel element caused the exhaust stack radiation alarm. The NCNR reactor has not been operated since the event. NCNR is currently conducting clean-up and repair activities. In accordance with Title 10 of the *Code of Federal Regulations* 50.36(c)(1) and NCNR Technical Specifications, NCNR must obtain NRC approval prior to resuming operations. The NRC's decision to approve any restart would be informed by, but would not be solely reliant upon, the Confirmatory Order discussed below.

The NRC's special inspection for the February 3, 2021, event documented seven apparent violations, the most significant being an apparent violation of NCNR Technical Specification 2.1, "Safety Limit," which states that the reactor fuel cladding temperature shall not exceed 842°F for any operating conditions of power and flow. The NRC inspectors observed once-molten material in and around a fuel element indicating that the fuel cladding temperature safety limit had been exceeded.

ADR sessions: May 10, 19, June 2

CO issued: August 1, 2022

CO deadline(s): through March 2027 (32% complete as of 12.22.2022)

## Contents

Completed corrective actions (visual latch verification)

Planned corrective actions (5<sup>th</sup> reactor operations shift)

Communications (NIST Director's message)

Nuclear safety program assessments

- Nuclear safety culture
- Nuclear operations, training, etc.
- Problem Identification and Resolution Program
- Employee Concerns Program
- Safety Culture Monitoring Panel

Training (refueling and requalification changes)

Procedures (procedure use & adherence)

Benchmarking (research & power reactors)

Employee Engagement (Rewards & Recognition Program)

Leadership Accountability (SEC, SC training, conference presentations, staffing)

Technical matters (assess options replacing reliance on admin controls for fuel latching, automatically secure CO<sub>2</sub> following SCRAM, configuration management)

# Improving Nuclear Safety Culture

NSCIP: benchmarking, continuous improvement, education, communications, monitoring & assessment

Baseline nuclear safety culture assessment performed with planned annual assessments.

Actions developed and implemented in response to assessment

Procedure Use & Adherence methods

HPI tools (e.g. pre-job briefs)

Weekly discussion of lessons-learned from safety incidents at NIST and elsewhere

POD meeting

Lessons from NIST incident shared in the community

Benchmarked nuclear safety culture at INL-ATR and ORNL-RRD and adopted several practices.

Nuclear Safety Culture Monitoring Panel

Employee Concerns Program

Rewards & Recognition Program (SGC&IP)

# External Consultants



**Dr. Julia Phillips**

Vice President & CTO, Sandia National Laboratory (retired), Executive Emeritus National Science Board



**Dr. Eric Kaler**

President, Case Western Reserve University



**Dr. Thom Mason**

Director, Los Alamos National Laboratory, President and CEO of Triad National Security, LLC (Triad)



**Alexander Adams, Jr.**

Chief, U.S. Nuclear Regulatory Commission Research and Test Reactors Licensing Branch (retired)

## Findings and Observations

“The importance of neutrons for research in important forefront areas of scientific inquiry, coupled with the dearth of other capacity for these experiments elsewhere in the U.S. makes it imperative to restart NCNR as soon as it is safe to do so.” – Julia Phillips (NSB)

“...the aborted re-entry on Feb 4 is noteworthy because over the course of the whole incident it represents the gravest threat to life that occurred...” – Thom Mason (LANL)

“The NCNR analyses of the root causes are also, I believe, comprehensive and accurate.” – Eric Kaler (CWRU)

“Observations during the site visit (Feb 1, 2022) showed a commitment to improving safety culture at all levels of NCNR management and staff.” – Al Adams

“NIST services (e.g. HR) do not seem to fully understand some of the differences in the environment in which NCNR operates relative to the rest of NIST. The fact that other federal entities (e.g. NRC) can compensate potential reactor operators at a much higher rate than NCNR can suggests that creativity and possibly advocacy on the part of HR may be required to address some of the most serious issues surrounding the restart and continued safe operation of NCNR.” – Julia Phillips (NSB)

# External Consultants

...beyond NCNR's initial corrective actions

<b>Recommendation</b>	<b>Action</b>
<p>Improve alignment and integration between NCNR and NIST-level programs (corporate support/oversight). Improve alignment and integration between NCNR and NIST/OSHE safety management.</p>	<p>NCNR Director and CSO coordinating in the development of new NIST-wide and NCNR programs.</p> <p>CSO is ex-officio member of reactor safety oversight committee. New NCNR Safety Program Coordinator highly engaged with OSHE staff. OSHE to embed a new safety staff member at NCNR.</p>
<p>Improve leadership engagement at NIST level.</p>	<p>NCNR Director provides annual reactor safety briefing for the NIST Director; ADMR and ADLP members of team providing oversight for meeting the requirements of the Confirmatory Order.</p>
<p>Elevate risk management of NCNR at the NIST-level, including reviews. Provide the resources needed for corrective actions in full.</p>	<p>NCNR unplanned outage tracked in the NIST Enterprise Risk Management system as among top two enterprise risks. Budget requirements communicated to NIST leadership and resources needed for corrective actions provided.</p>
<p>OHRM should explore creative options to recruit, retain, and hire reactor operators, including exploring position classification for reactor operators to compete with industry.</p>	<p>In progress.</p>

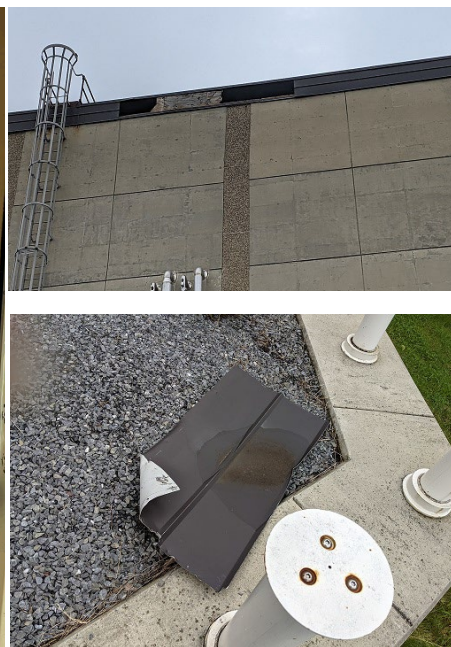
“Skepticism about management’s ability to secure the necessary financial resources for a fifth shift can also be traced to staff observation of the difficulty in resolving long-standing safety concerns of a non-nuclear nature (examples cited include ladders and stairwells). This reflects a NIST challenge of deferred maintenance and insufficient funding to address infrastructure deficiencies that is not limited to NCNR however ***the inadvertent message sent to staff*** that impacts the nuclear safety culture ***is that safety is not as important as the marquee scientific investments that do attract funding.***” – Thom Mason (LANL)

“In short, the NCNR Director has the responsibility for the safe operation of NCNR but lacks the authority and resources to implement some actions required to ensure safe operations.” – Julia Phillips (NSB)

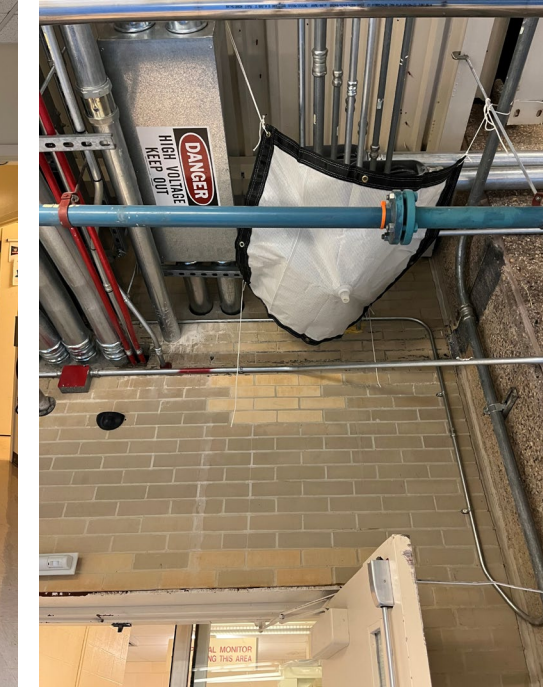
# Issues Management



Emergency doors need to be replaced.



Falling roof flashing – hazard to personnel.

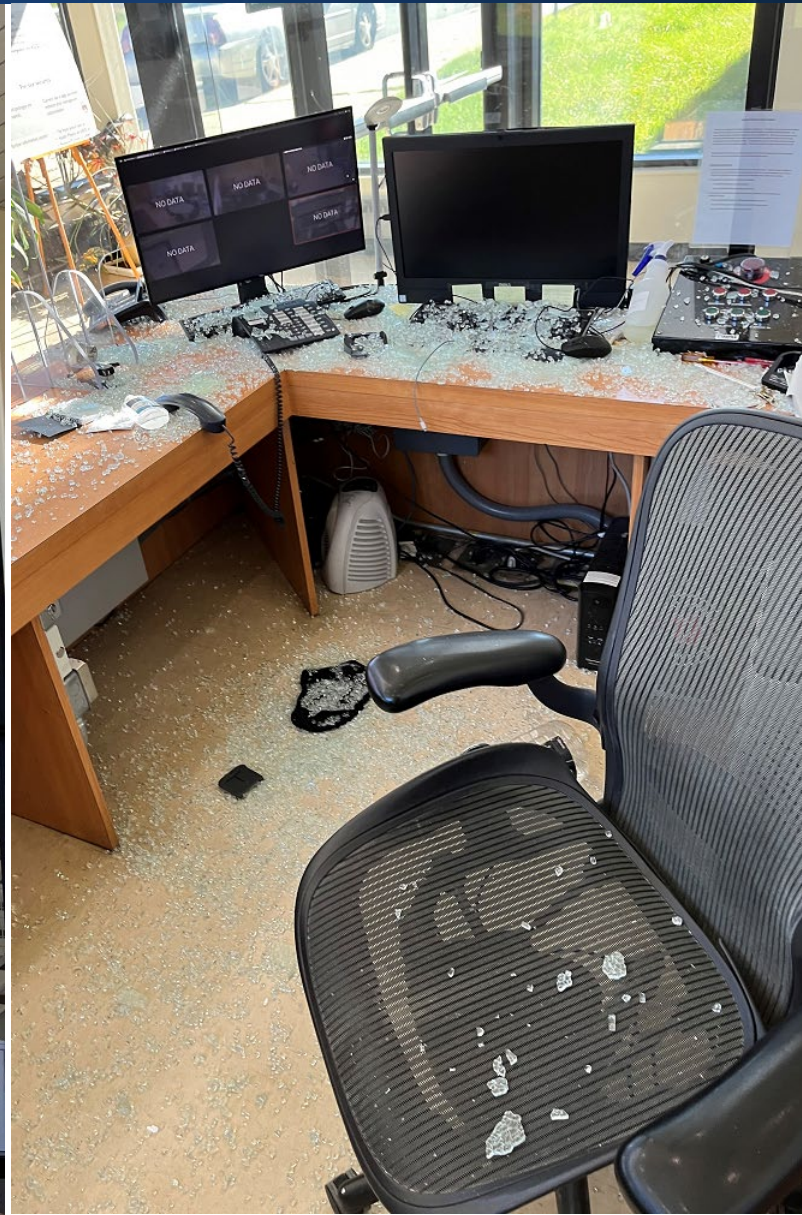


Aging site steam system leaks resulted in unplanned outages for repairs and unanticipated emergent hazards.

Unresolved water leaks: Leak diverters used as long-term water leak control measures (note that Guide Hall leak diverter is near electrical equipment).



# Issues Management



# Three things that impact NIST safety and culture

**Issues management 1** – NIST lacks the capacity to address infrastructure issues in a timely manner.

**Issues management 2** – NIST lacks a centralized, integrated, corporate-wide IT system that supports all aspects of issues management and allows managers to monitor safety performance quickly and easily. (e.g. reporting issues and tracking corrective actions from inspections, incident investigations and other input; data queries/reports; asset management; management observations, maintenance work requests, lessons-learned, employee suggestions, etc.). The current “system” is composed of a set of unconnected applications that are a pain point for users as well as managers who seek to pull data to assess performance.

**Telework** – The safety culture in an operationally-driven organization like a laboratory or user facility is best nurtured and maintained through in-person engagement. It is especially critical for supervisors to be on-site and present during laboratory operations planning and performance. ***As scientific operations continue to build tempo towards pre-pandemic levels, full on-site staffing should be the starting point. Only after the organization has gained relevant experience with full operations should telework and remote work be considered and phased in with a watchful eye on safety culture and safe operations.***